Uinta Basin Oil and Gas Production Model

Summary and Long-Term Projections

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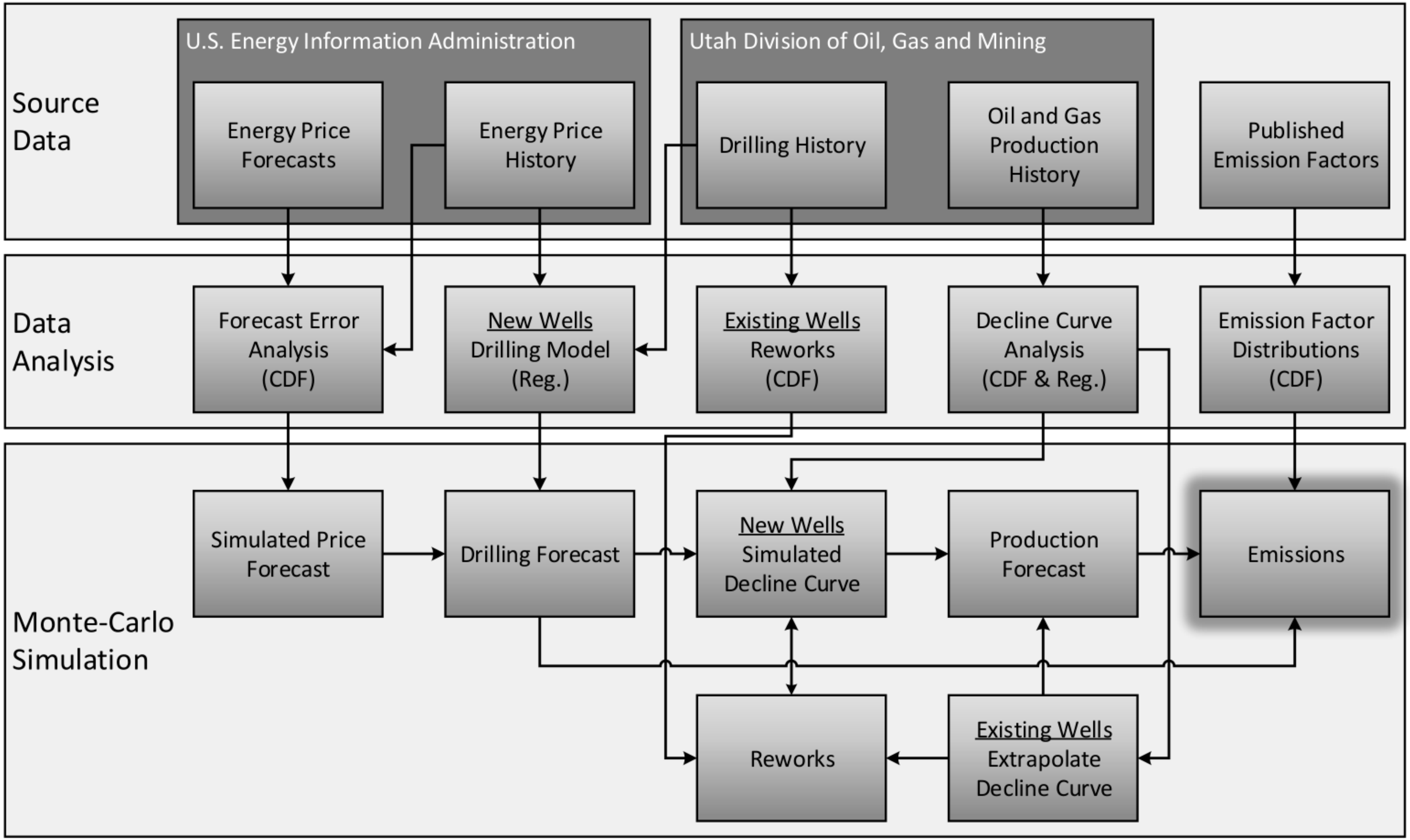
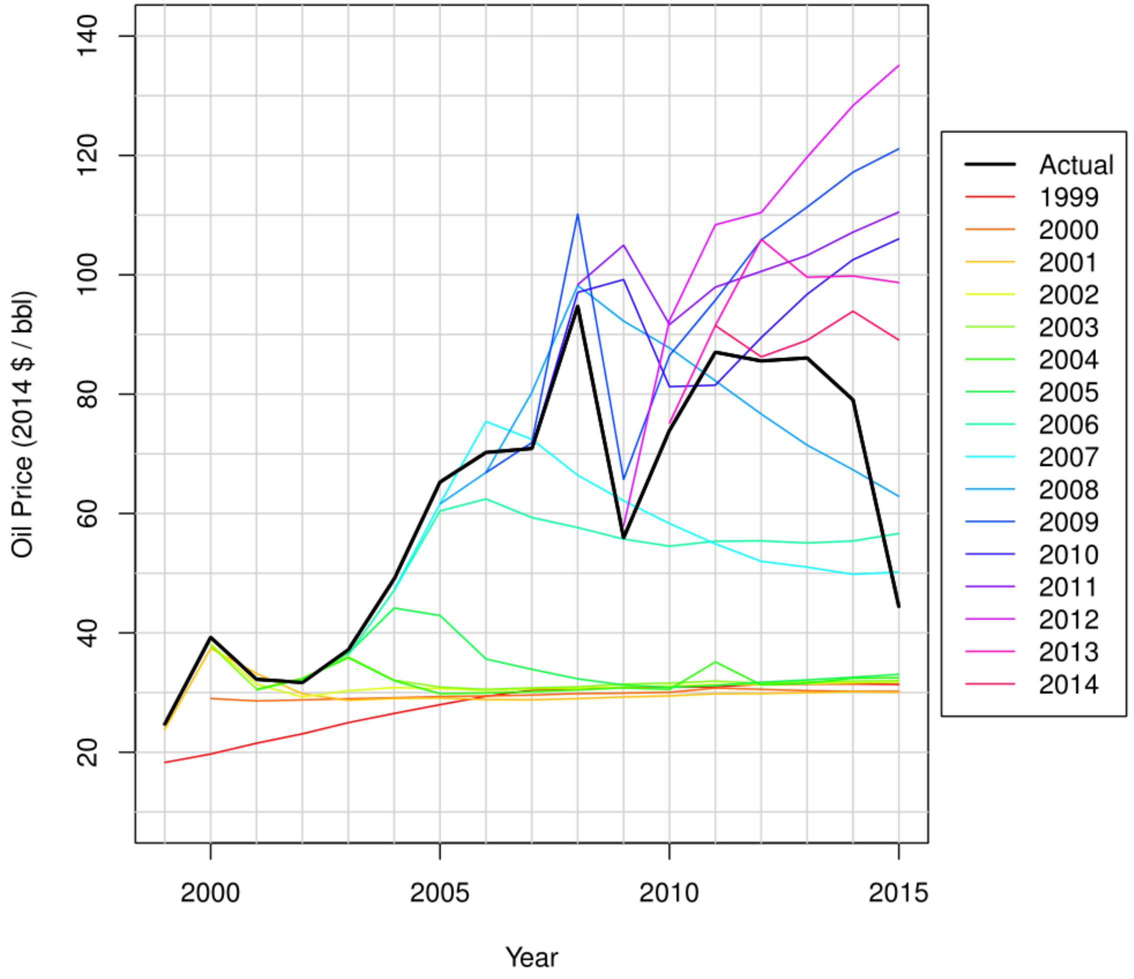
November 24, 2015


Source Data
U.S. Energy Information Administration
Energy Price Forecasts
Energy Price History
Utah Division of Oil, Gas and Mining
Drilling History
Oil and Gas Production History
Published Emission Factors
Data Analysis
Forecast Error Analysis (CDF)
New Wells Drilling Model (Reg.)
Existing Wells Reworks (CDF)
Decline Curve Analysis (CDF & Reg.)
Emission Factor Distributions (CDF)
Monte-Carlo Simulation
Simulated Price Forecast
Drilling Forecast
New Wells Simulated Decline Curve
Production Forecast
Emissions
Reworks
Existing Wells Extrapolate Decline Curve

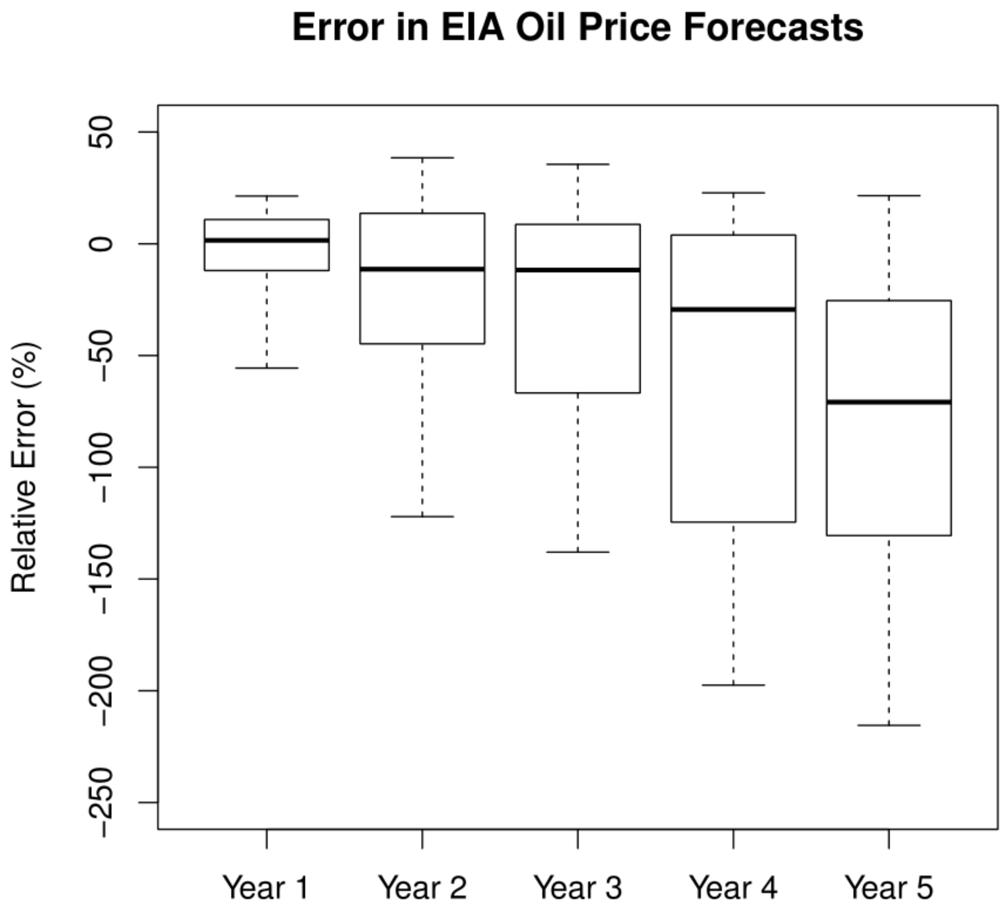
Simulated Price Forecast

- Current method
  - Based on EIA Annual Energy Outlook



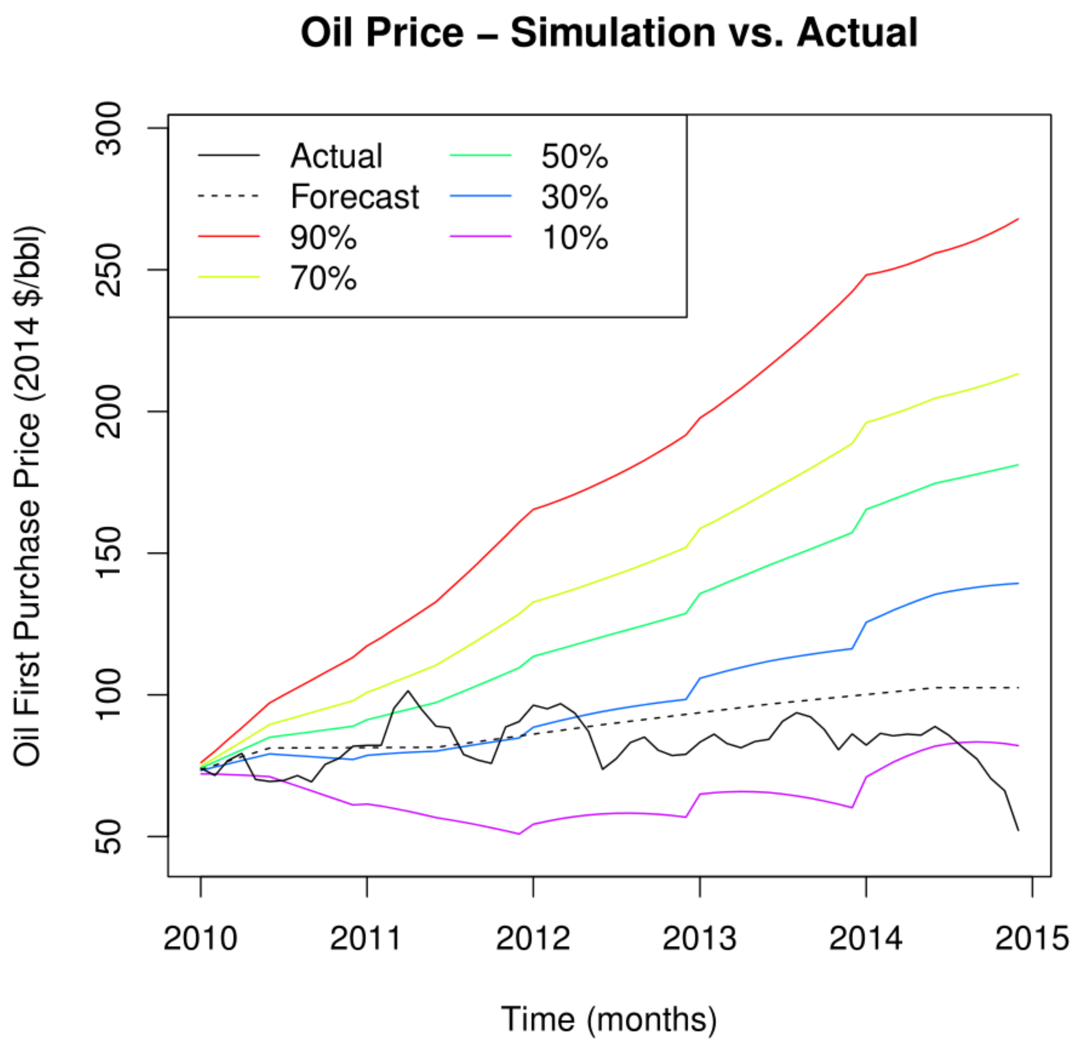
Simulated Price Forecast

- Current method
  - Based on EIA Annual Energy Outlook
  - $RE = \frac{FP-AP}{FP}$



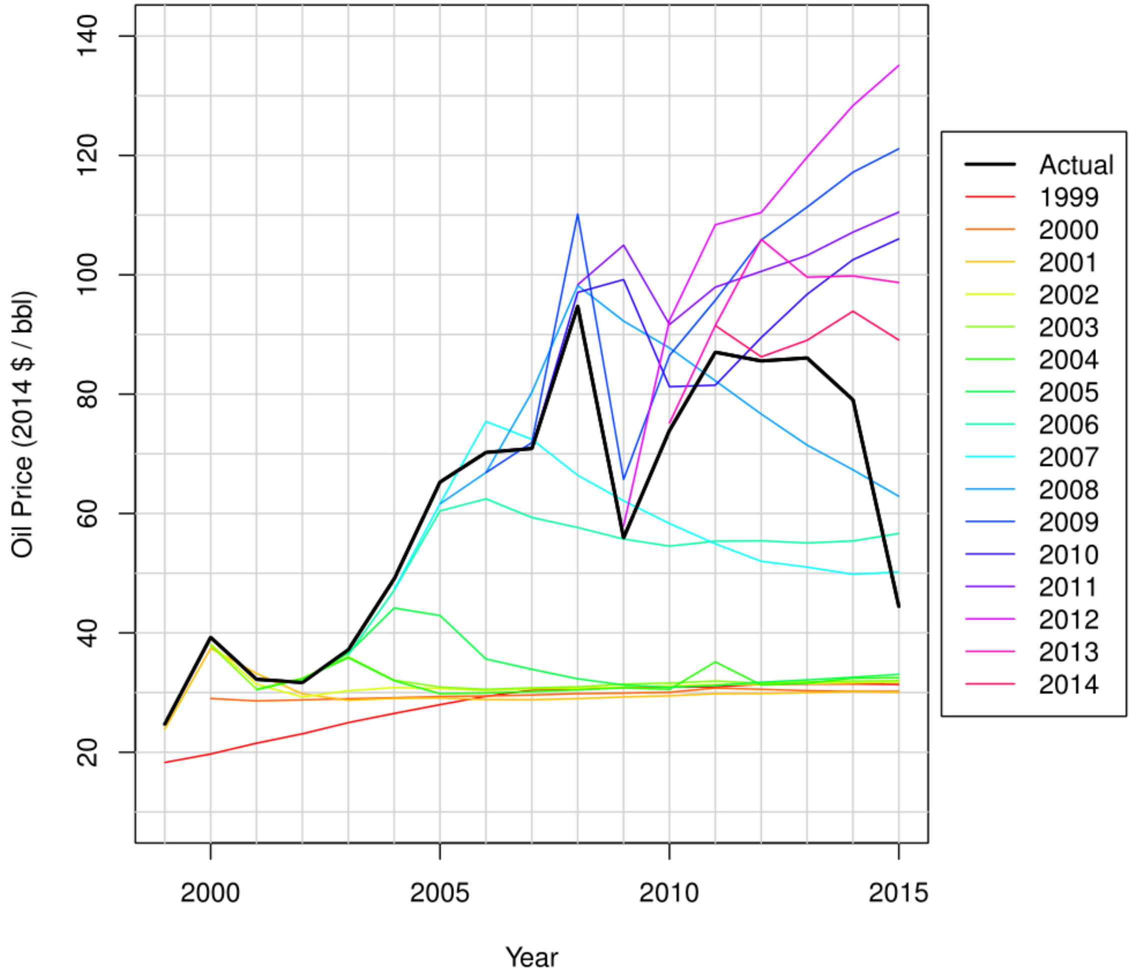
Simulated Price Forecast

- Current method
  - Based on EIA Annual Energy Outlook
  - $RE = \frac{FP - AP}{FP}$
  - Find simulated price by randomly picking values of *RE*



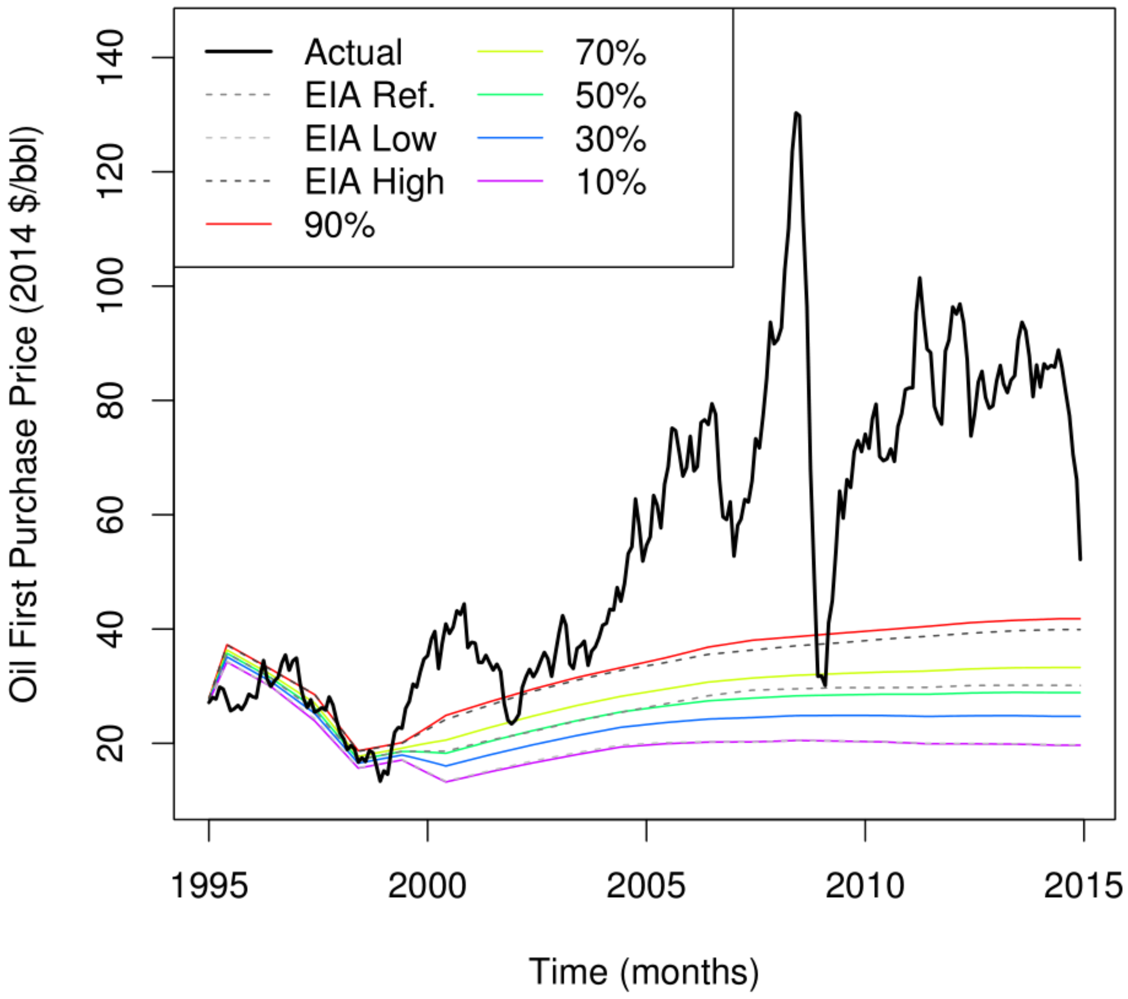
Simulated Price Forecast

- 20-yr projection problem
  - Not enough data to use *RE* method



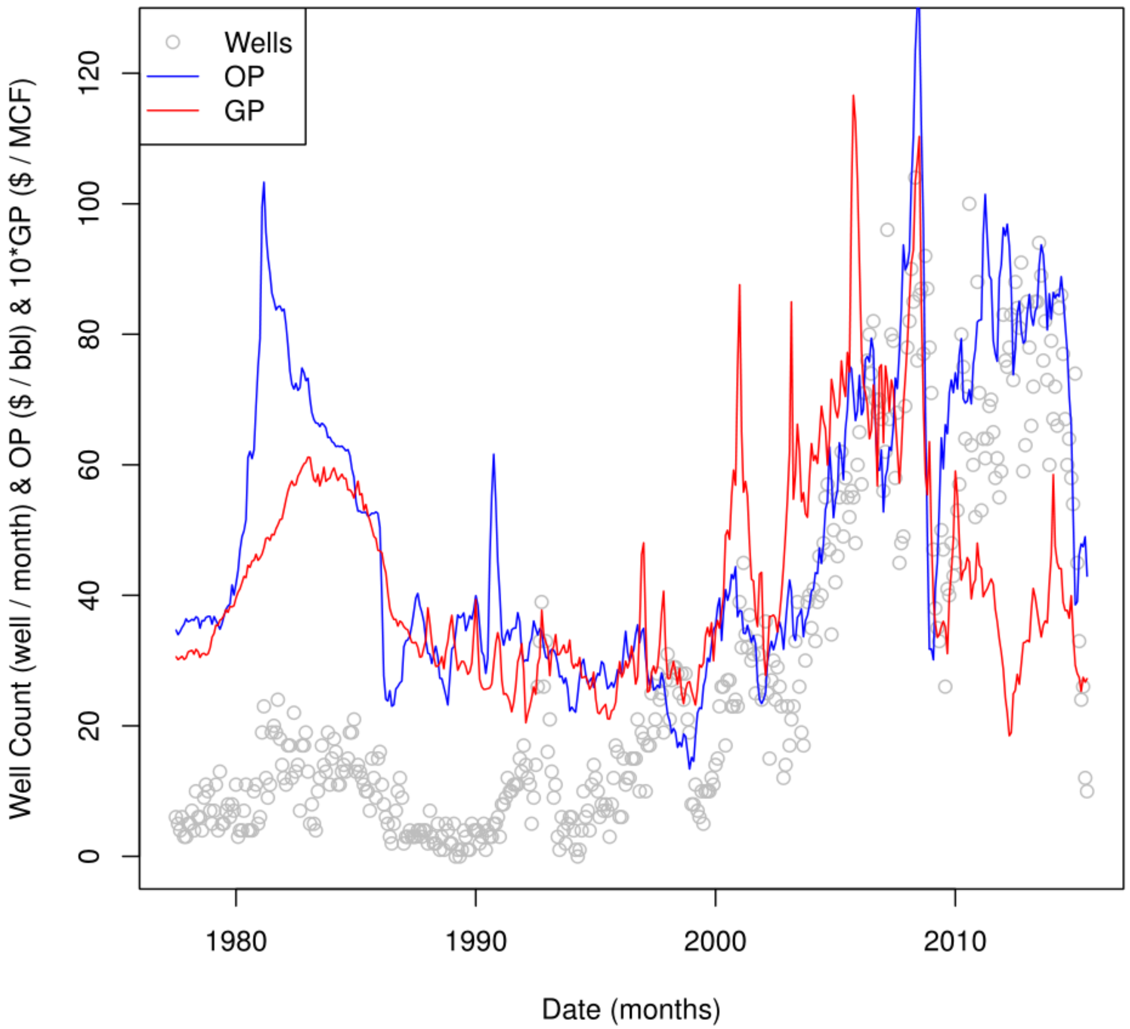
Simulated Price Forecast

- 20-yr projection problem
  - Not enough data to use *RE* method
- Options
  - EIA only method
    - Assume probability distribution
    - Fit to EIA low/reference/high forecasts
  - Meta-model with forecasts from more sources
  - Constant *RE* after 5 years
  - Random walk of ΔRE



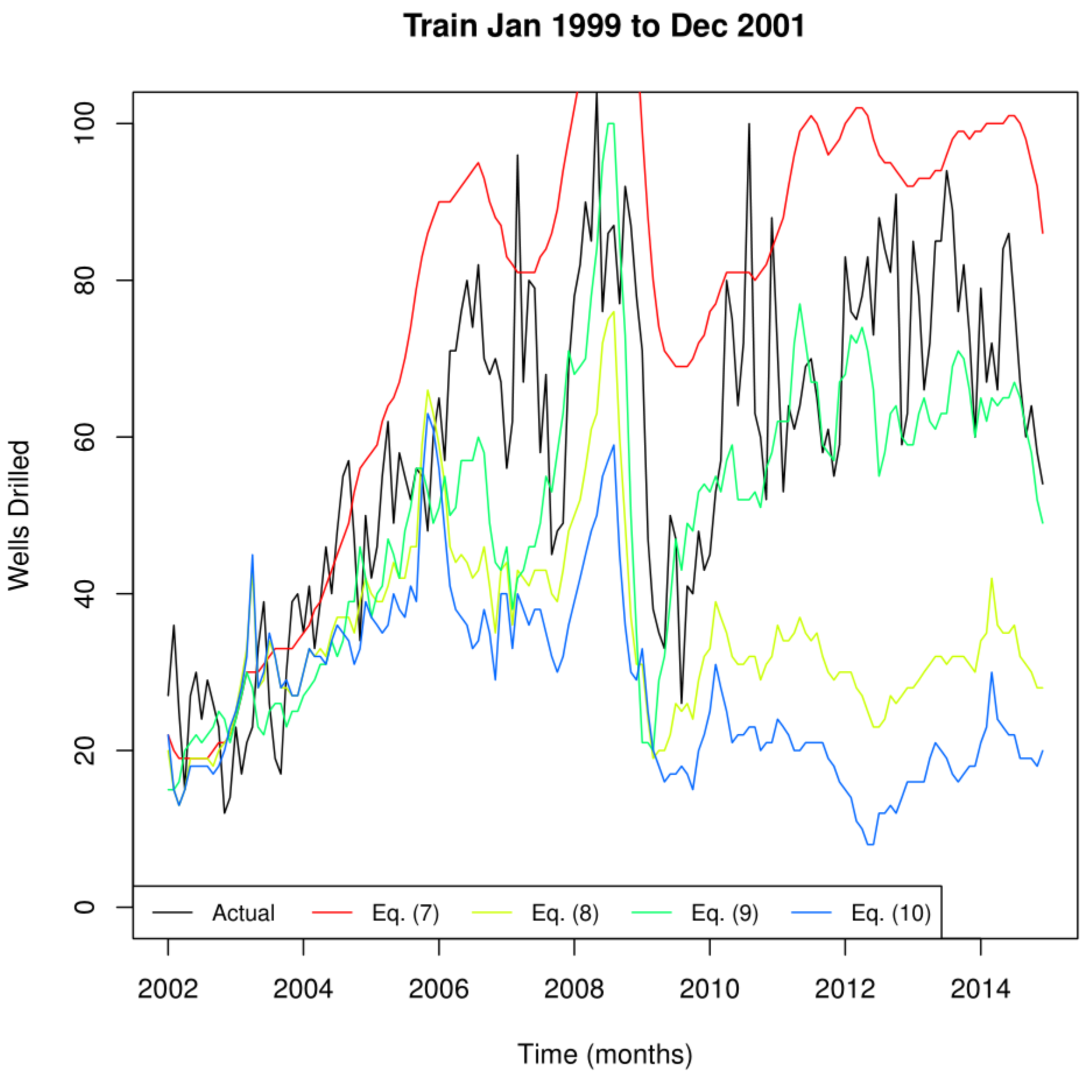
Drilling Forecast

- # of wells drilled f(energy prices)
  - EP and drilling correlated after 2000



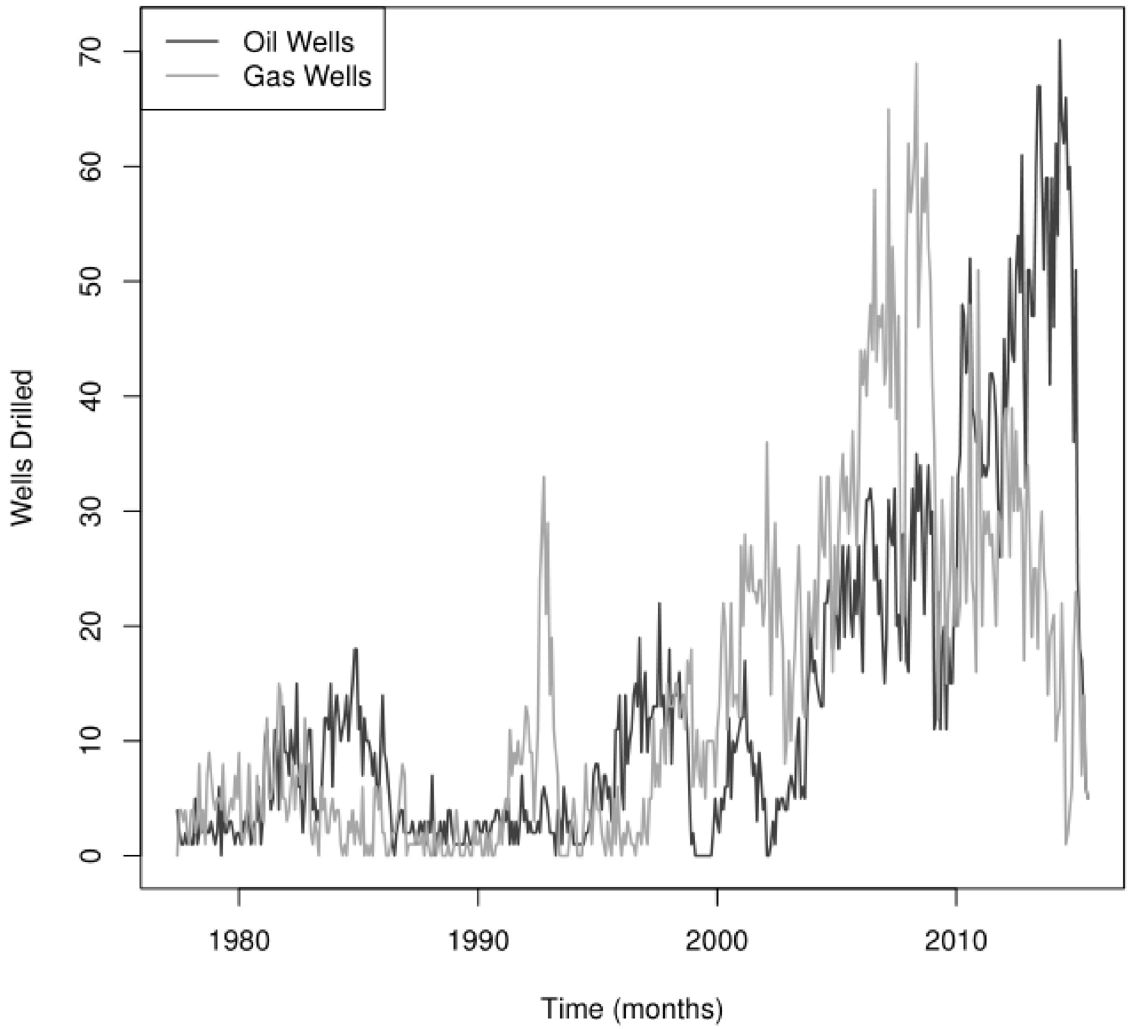
Drilling Forecast

- # of wells drilled f(energy prices)
  - EP and drilling correlated after 2000
  - Tested 4 models:
    - [7]: $W_t = aOP_t + bGP_t + cW_{t-1} + d$
    - [8]: $W_t = aOP_{t-1} + bGP_{t-1} + c$
    - [9]: $W_t = aOP_{t-1} + b$
    - [10]: $W_t = aGP_{t-1} + b$
  - Eq. [9] has best performance
    - Can be used as-is for long-term projection
    - Error from simulated price forecast > drilling model



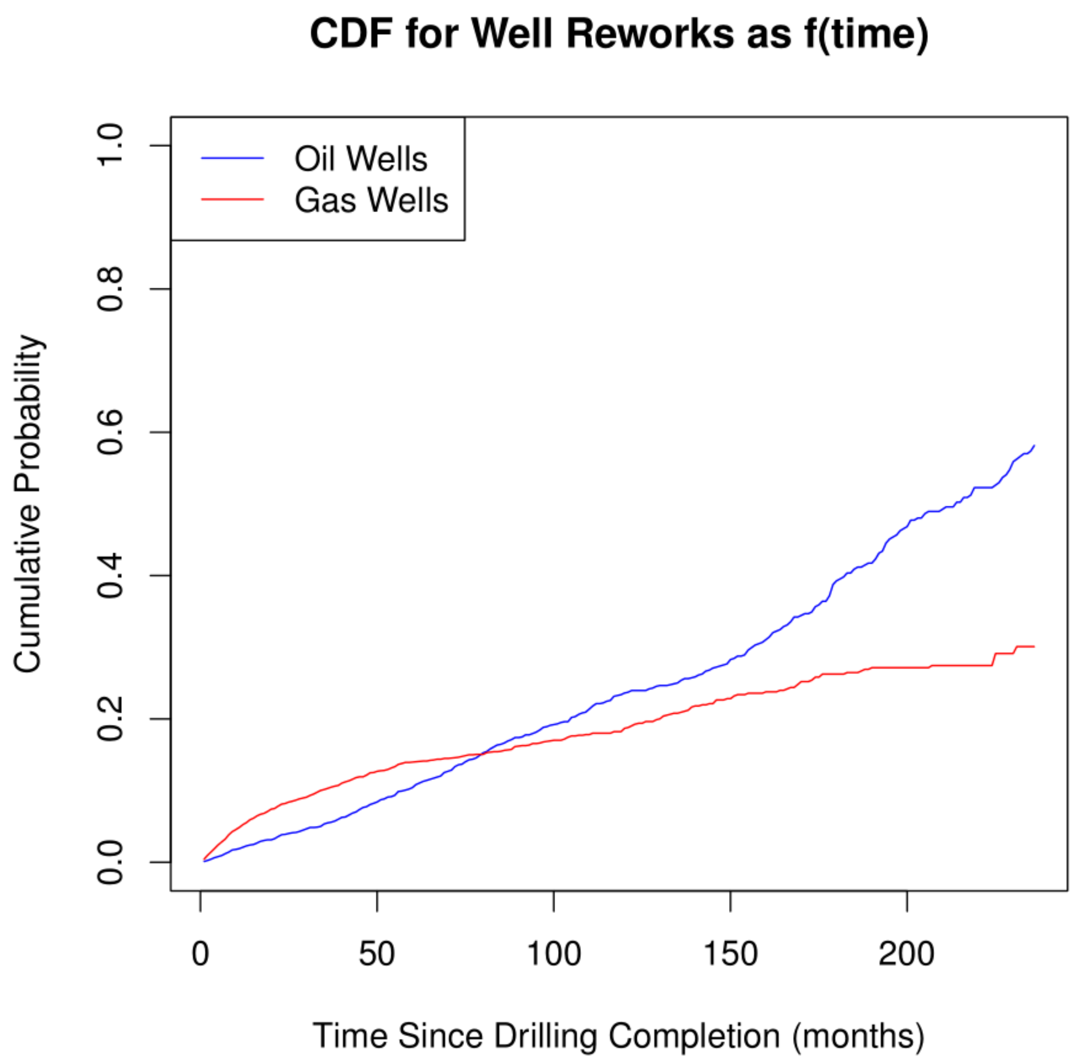
Well Type and Location

- Location
  - Model uses DOGM field numbers
  - Assuming new wells distributed to existing fields using same distribution as existing wells
- Well Type
  - Oil, gas, or dry
  - Probability of each is location specific
- Location and well type are assumed to be constant



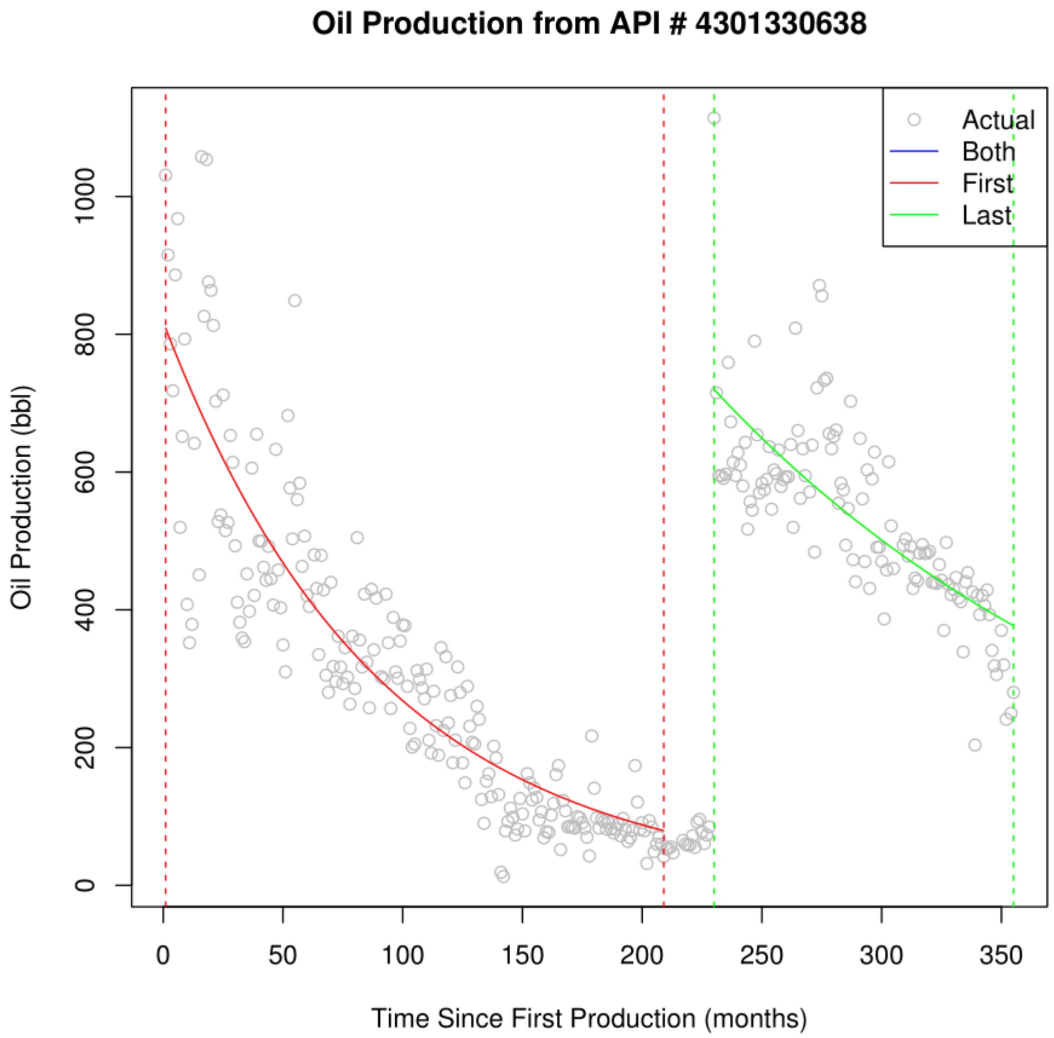
Reworks

- Any well (new or existing) could potentially be reworked
- Currently estimating when reworks occur as f(time)
- Reworked wells are treated as new wells by model
- Reworks that occur before or after modeling period are effectively ignored



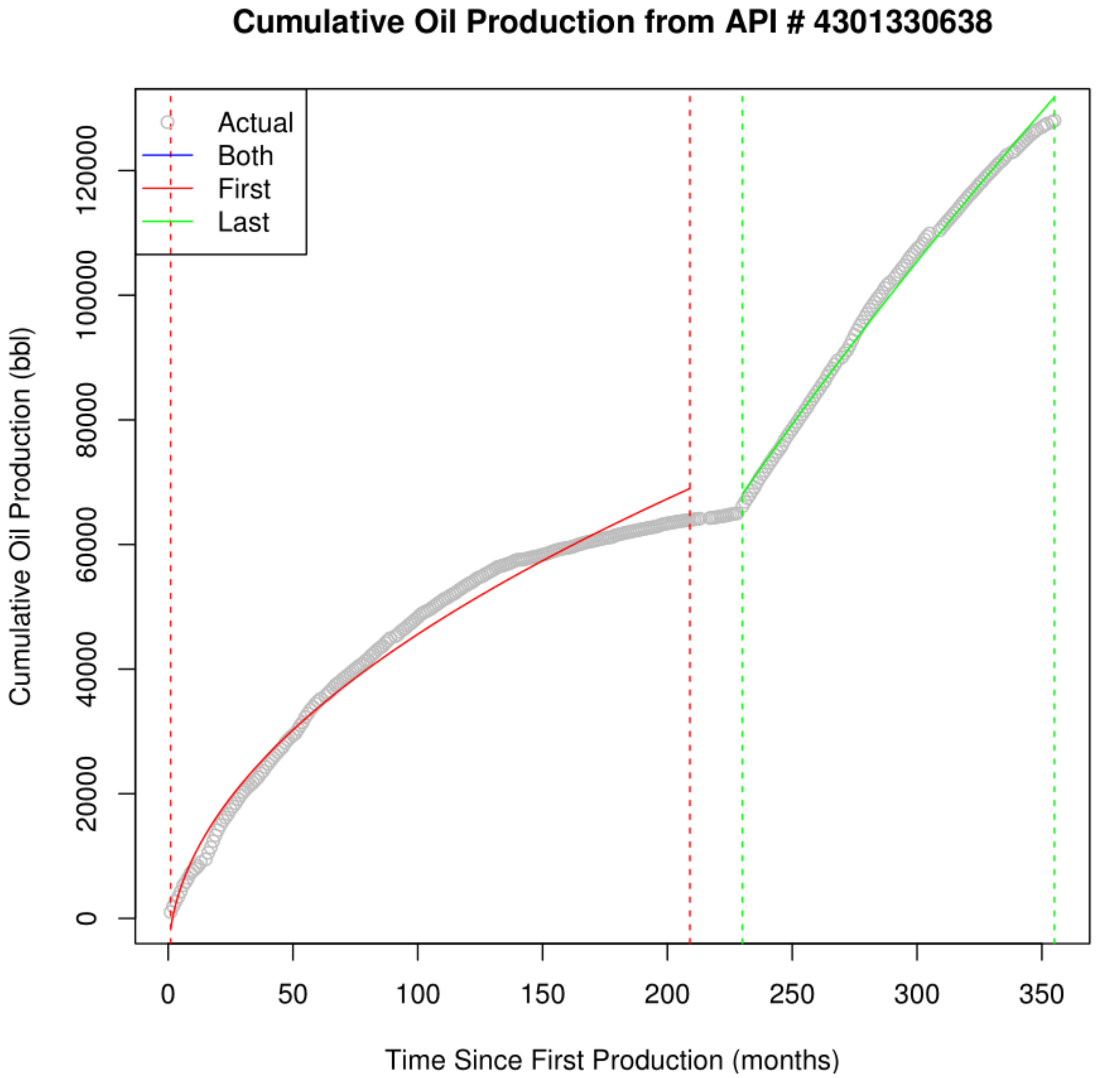
Production Forecast

- Two approaches
  - Existing wells
    - Hyperbolic decline curve
    - $q(t) = q_o(1 + bD_i t)^{-\frac{1}{b}}$



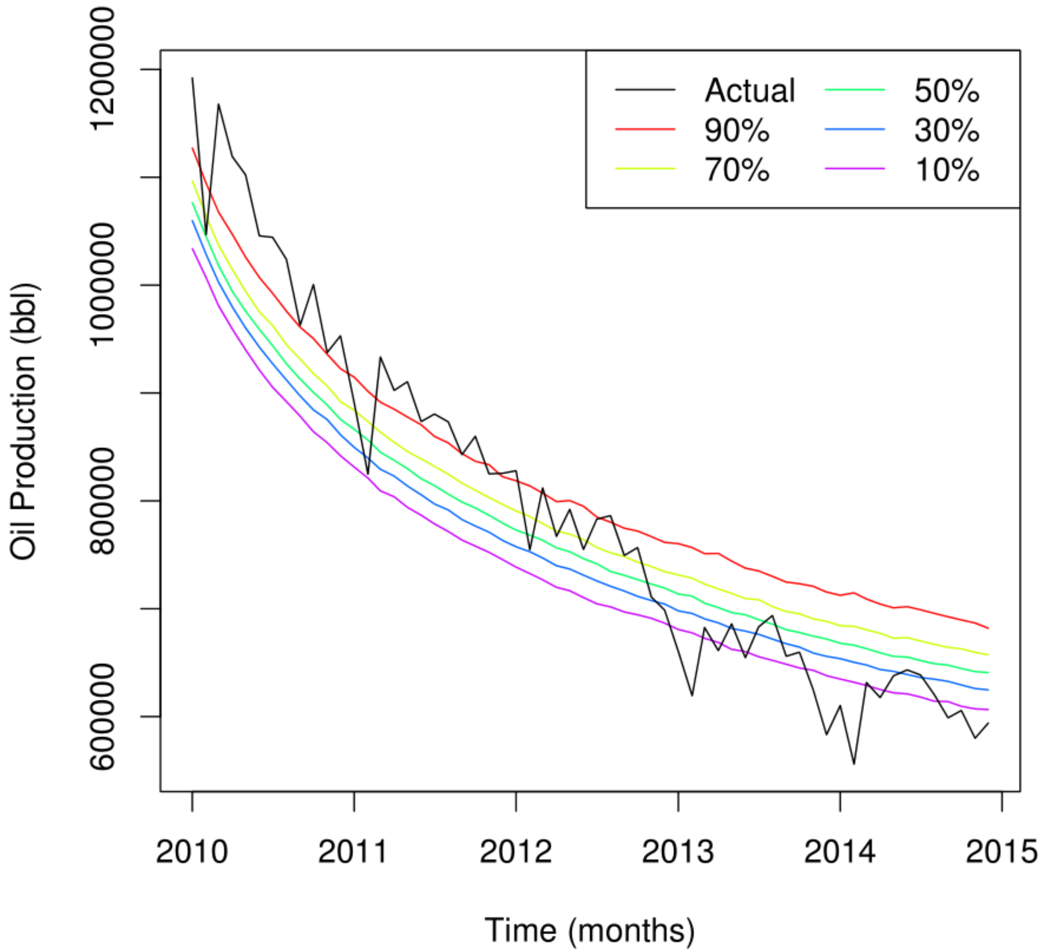
Production Forecast

- Two approaches
  - Existing wells
    - Hyperbolic decline curve
    - $q(t) = q_o(1 + bD_i t)^{-\frac{1}{b}}$
  - New wells
    - Cumulative production curve
    - $Q(t) = C_p\sqrt{t} + c_1$

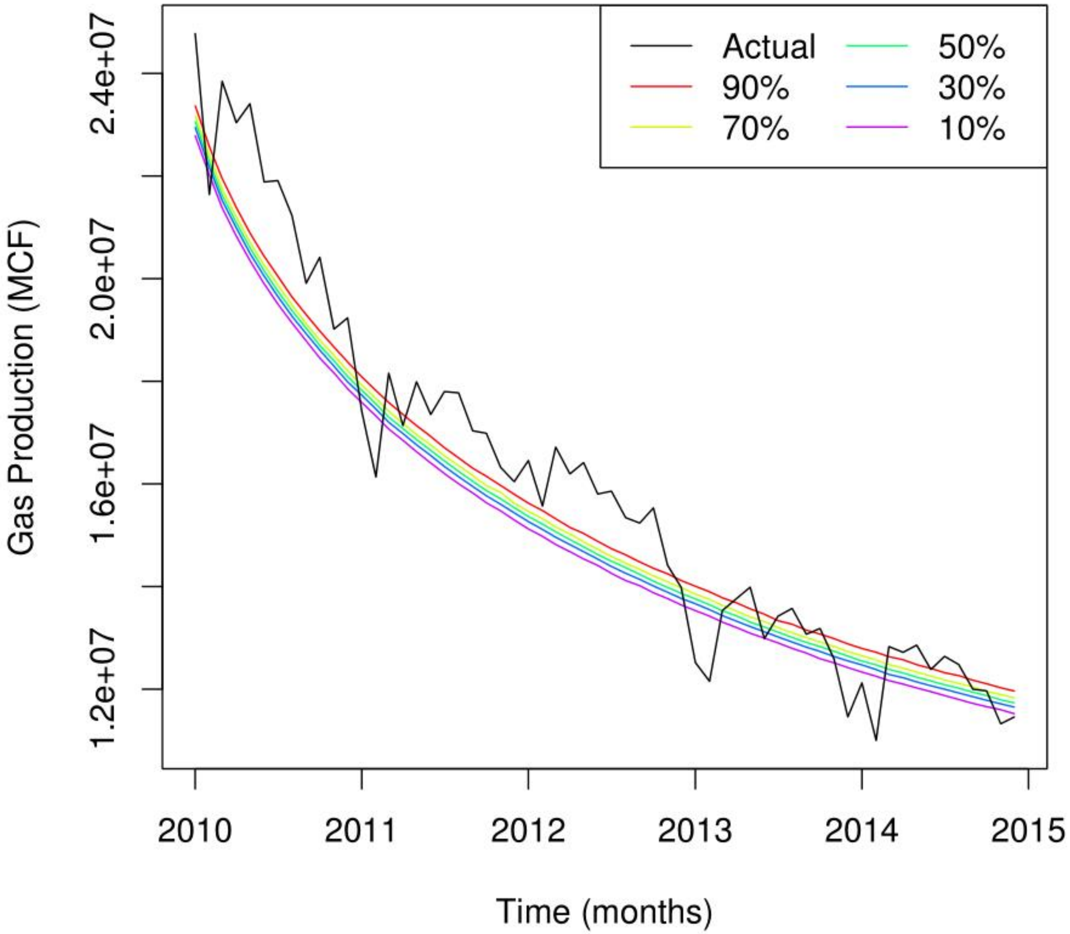


Existing Wells – 5 years

Oil

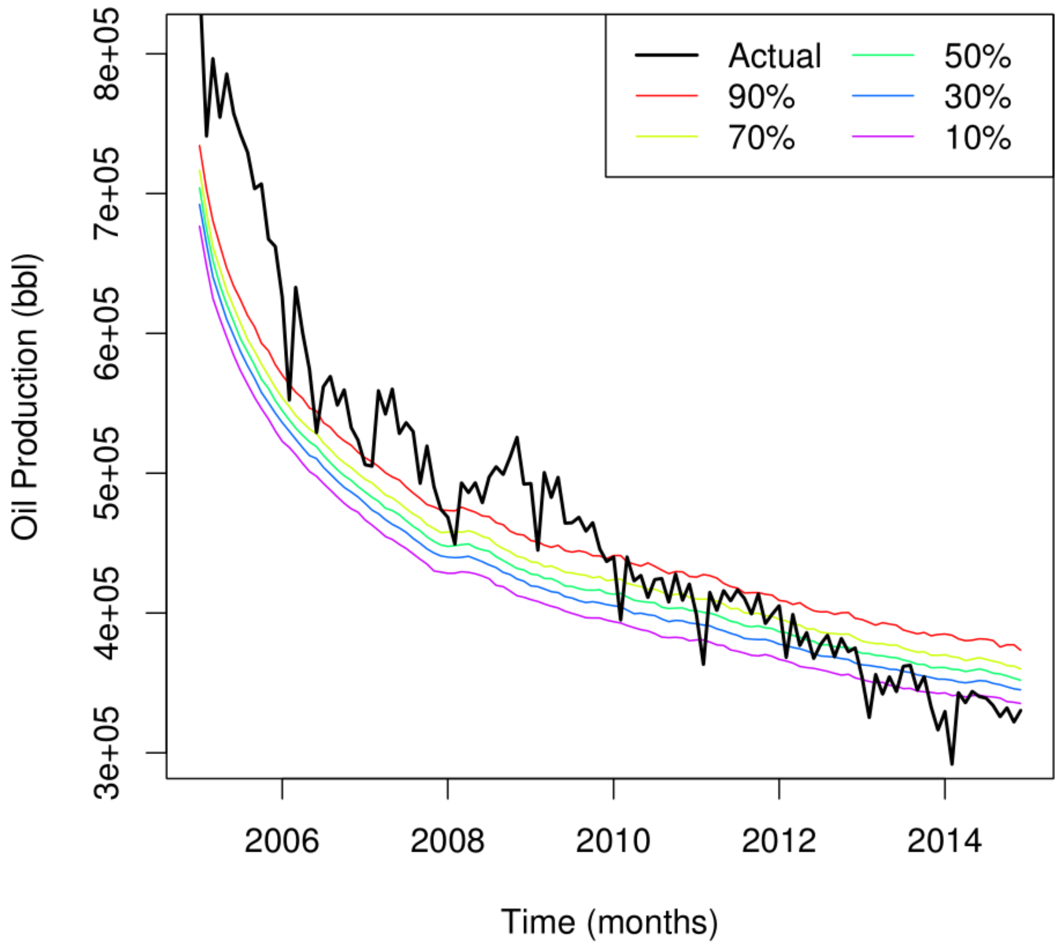


Gas

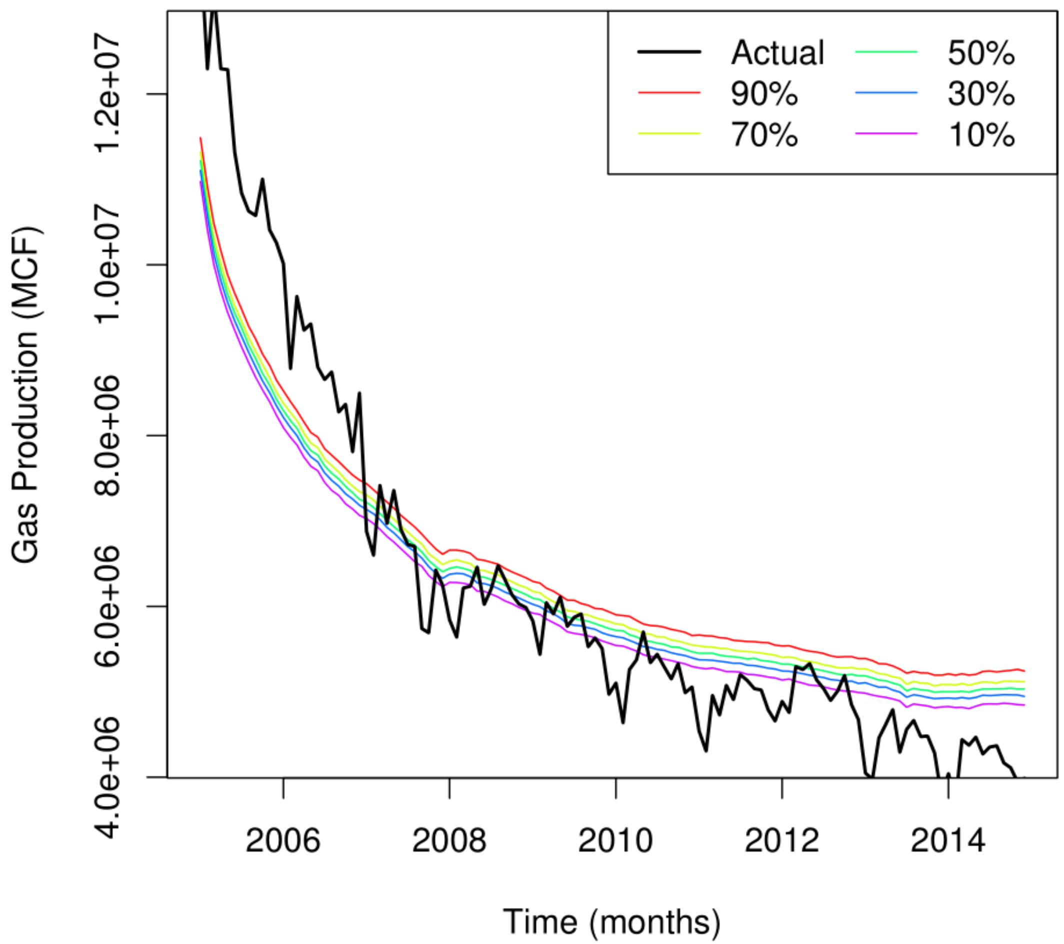


Existing Wells – 10 years

Oil

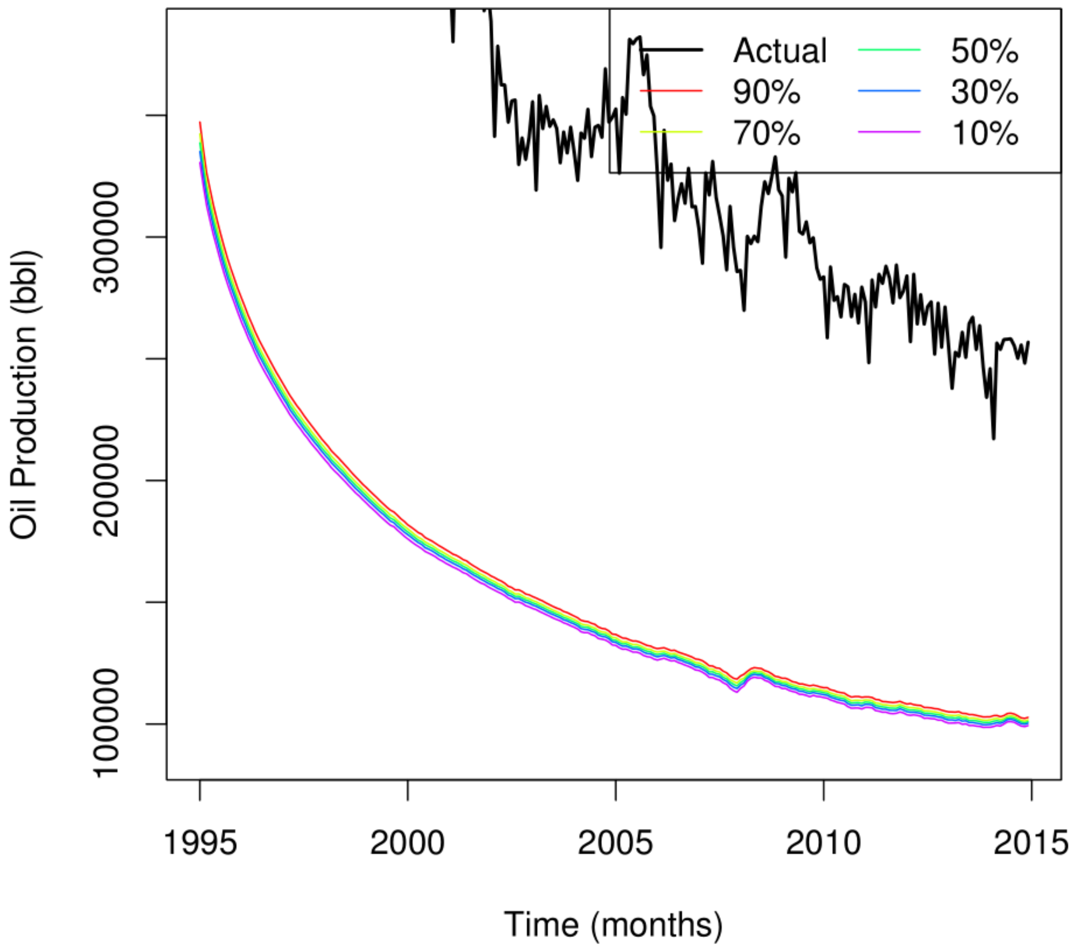


Gas

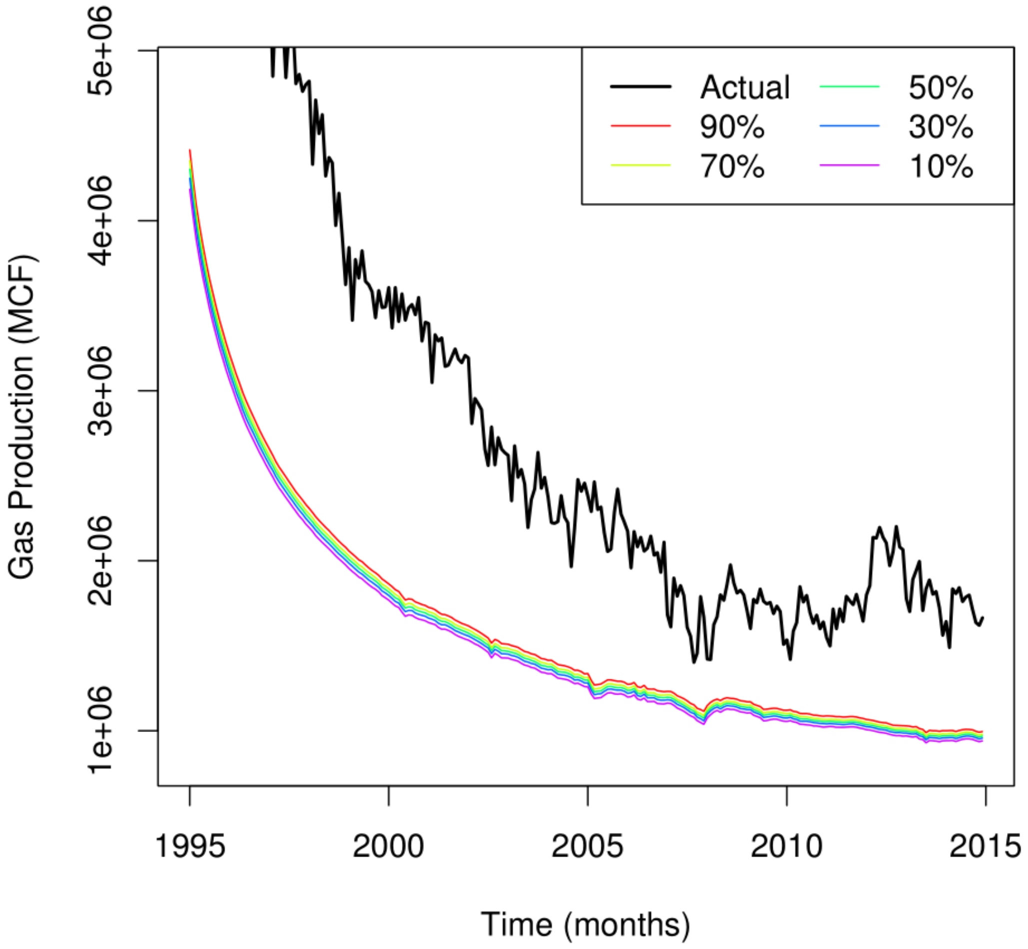


Existing Wells – 20 years

Oil

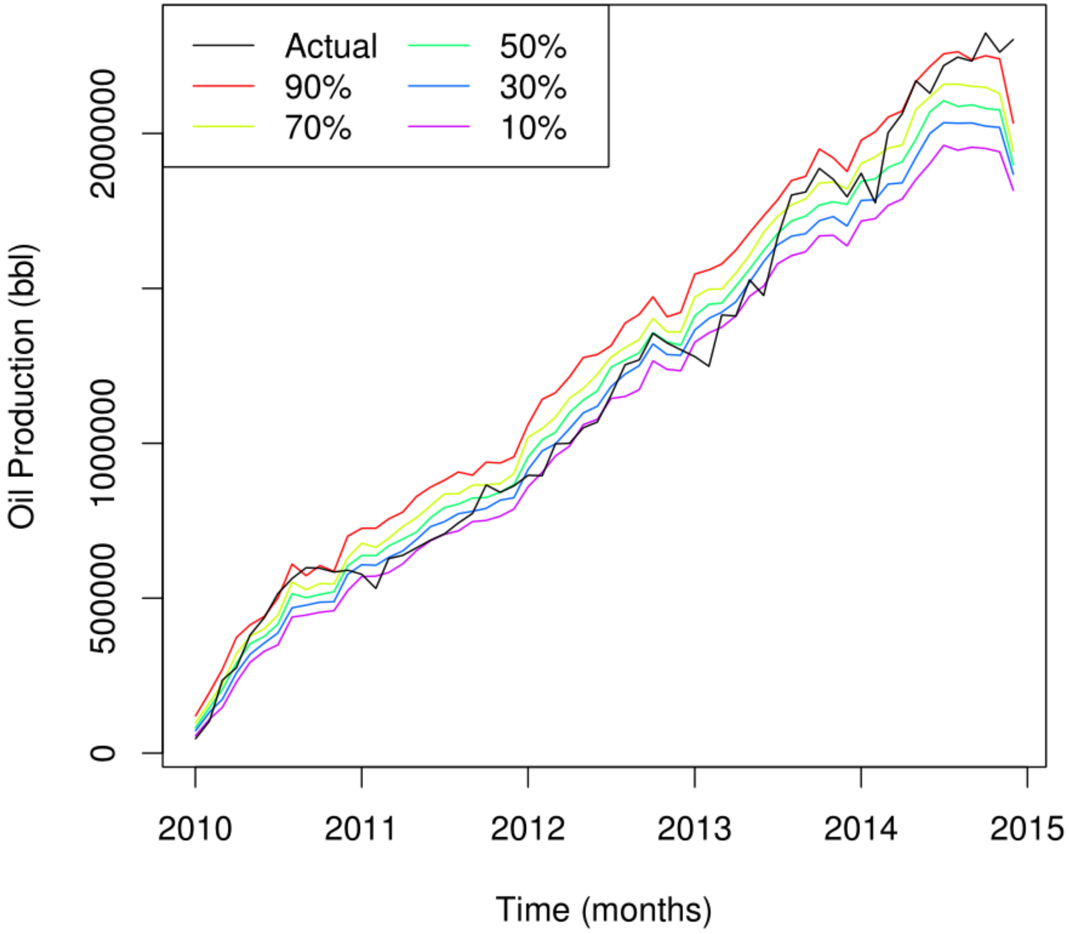


Gas

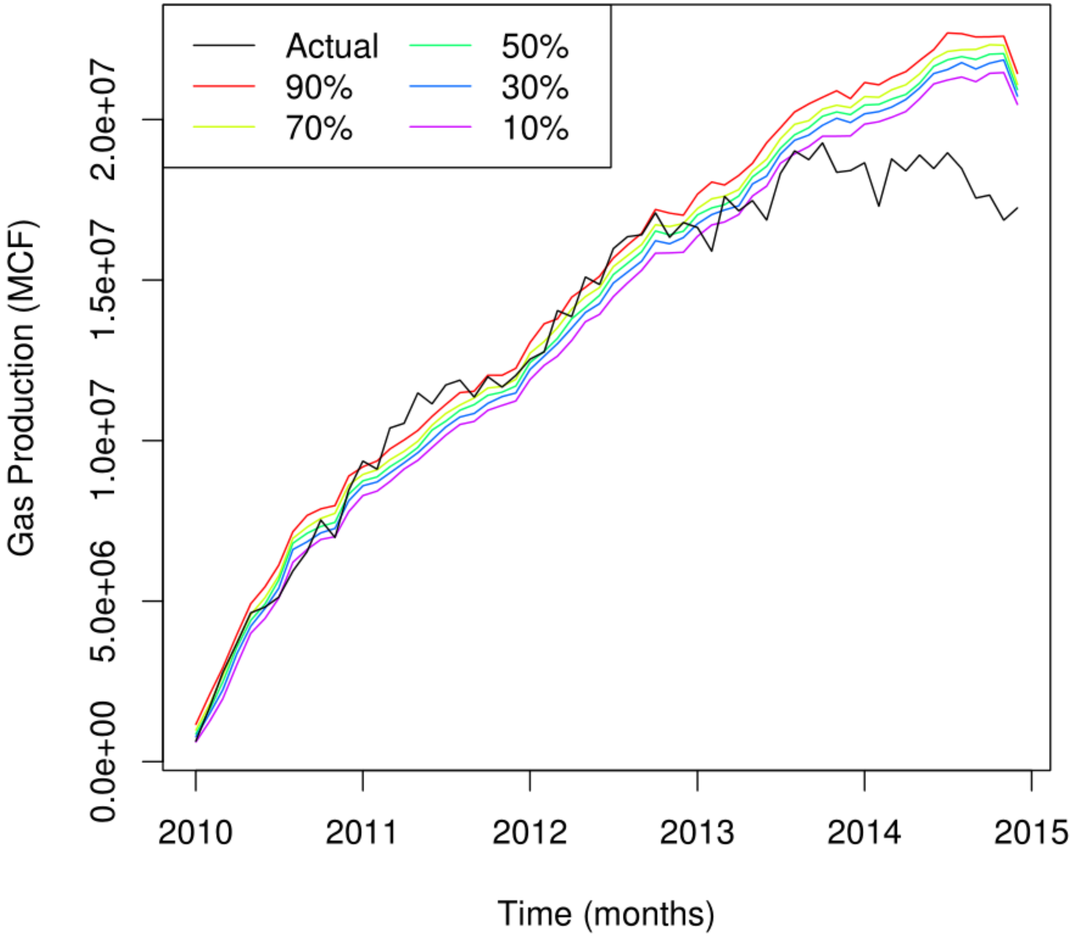


New Wells – 5 years

Oil

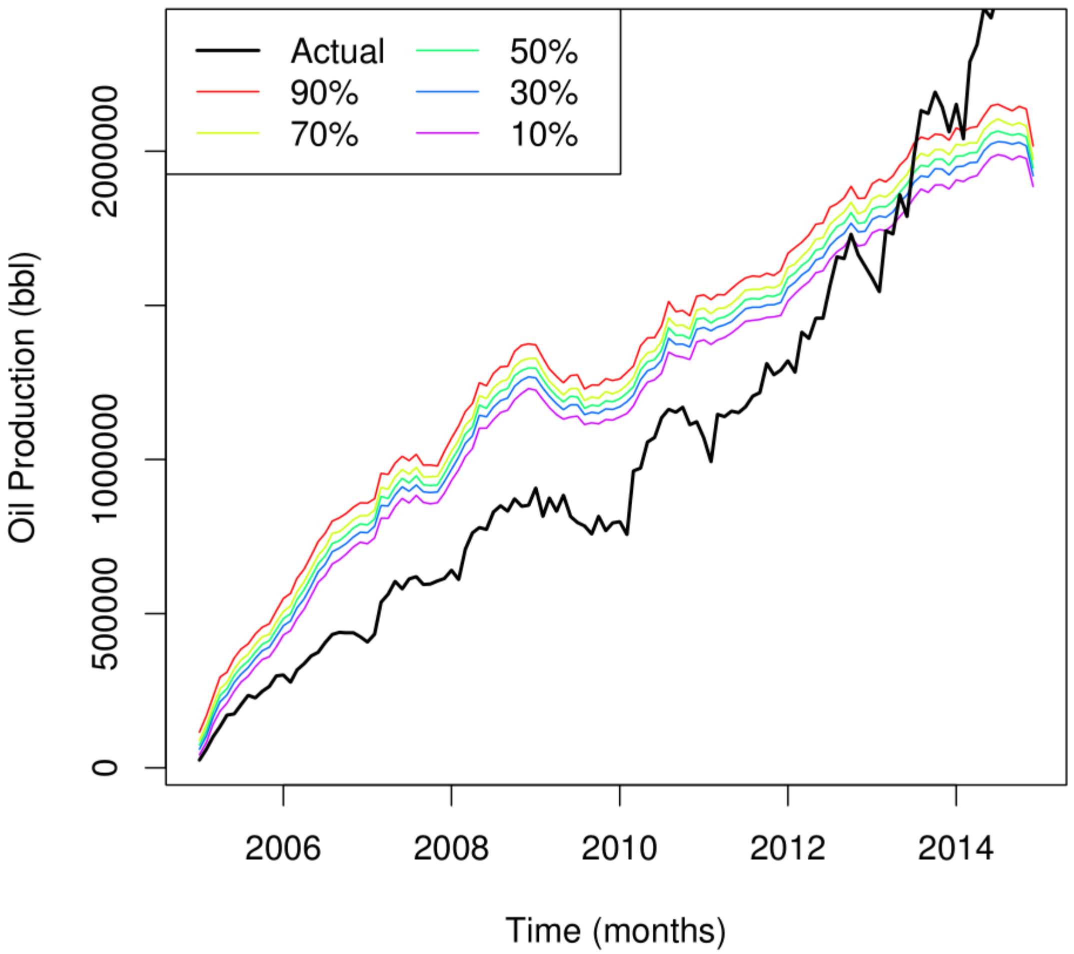


Gas

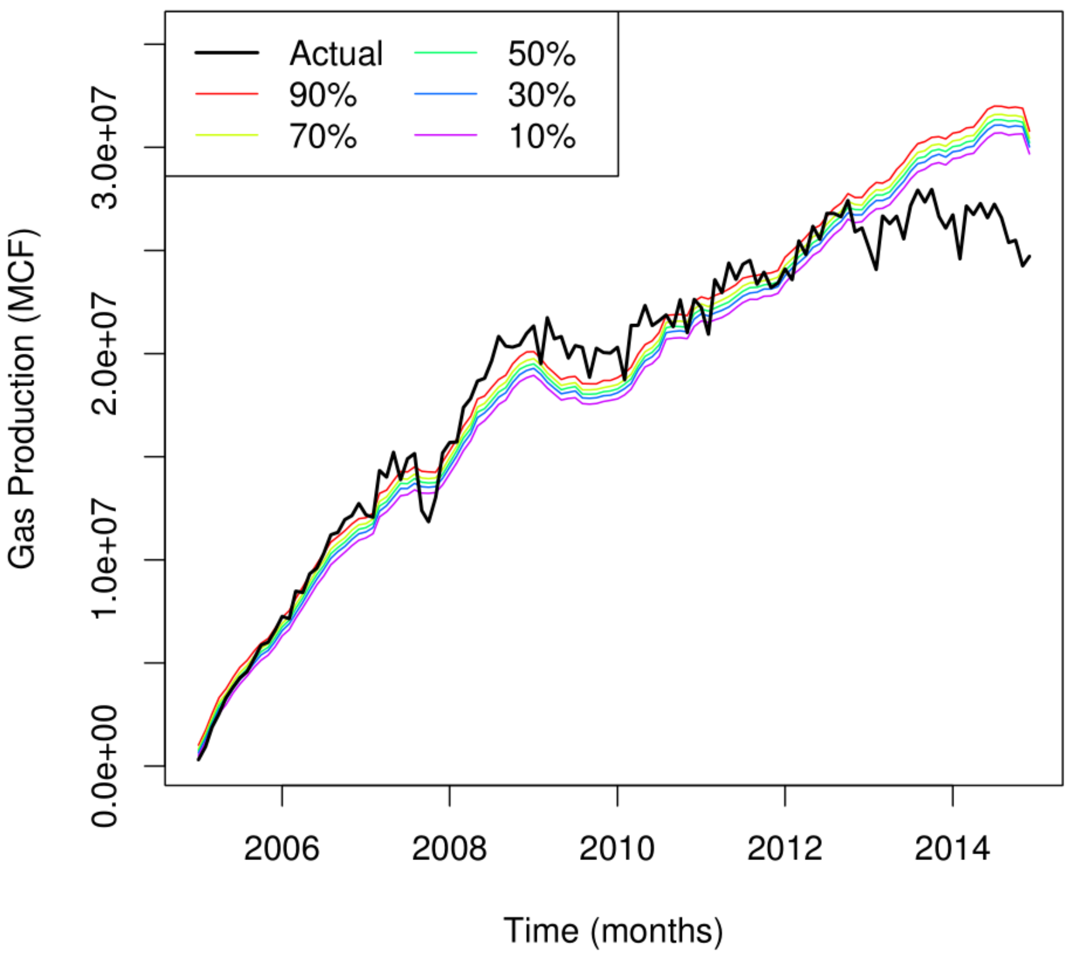


New Wells – 10 years

Oil

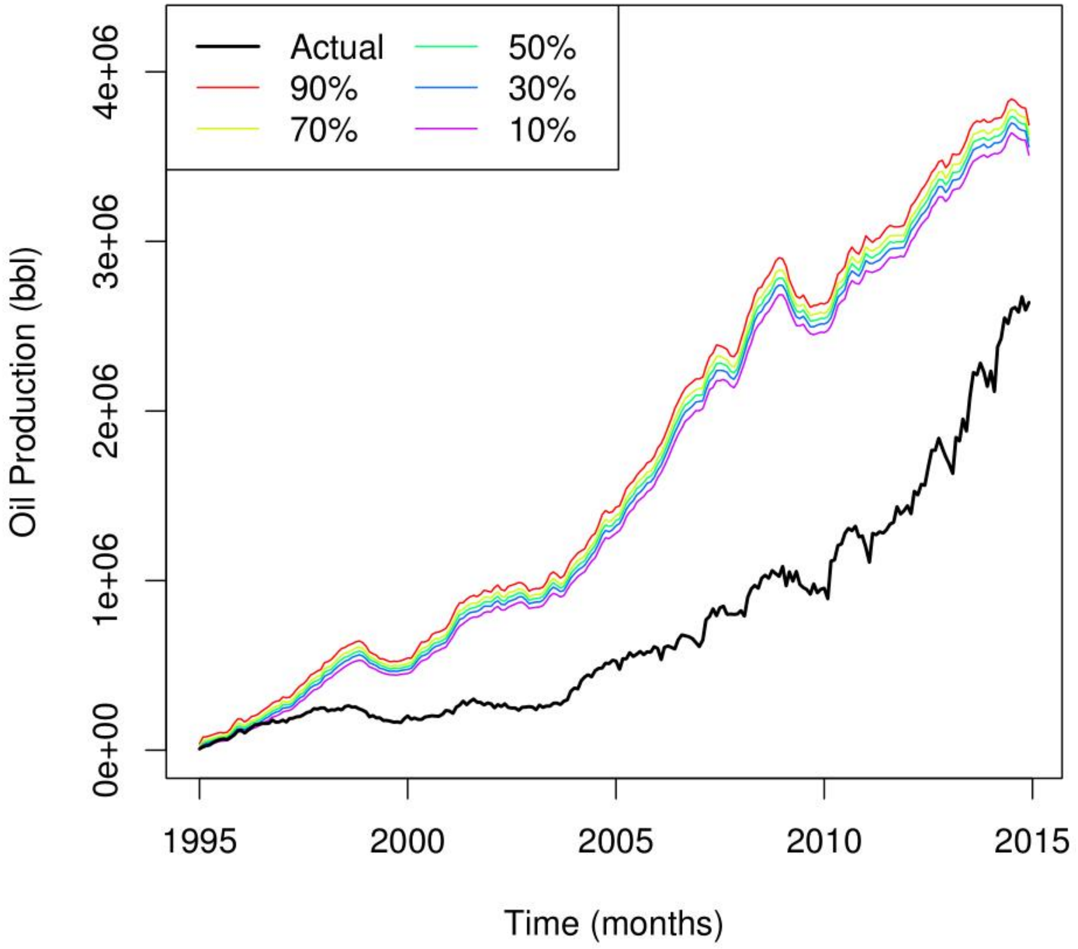


Gas

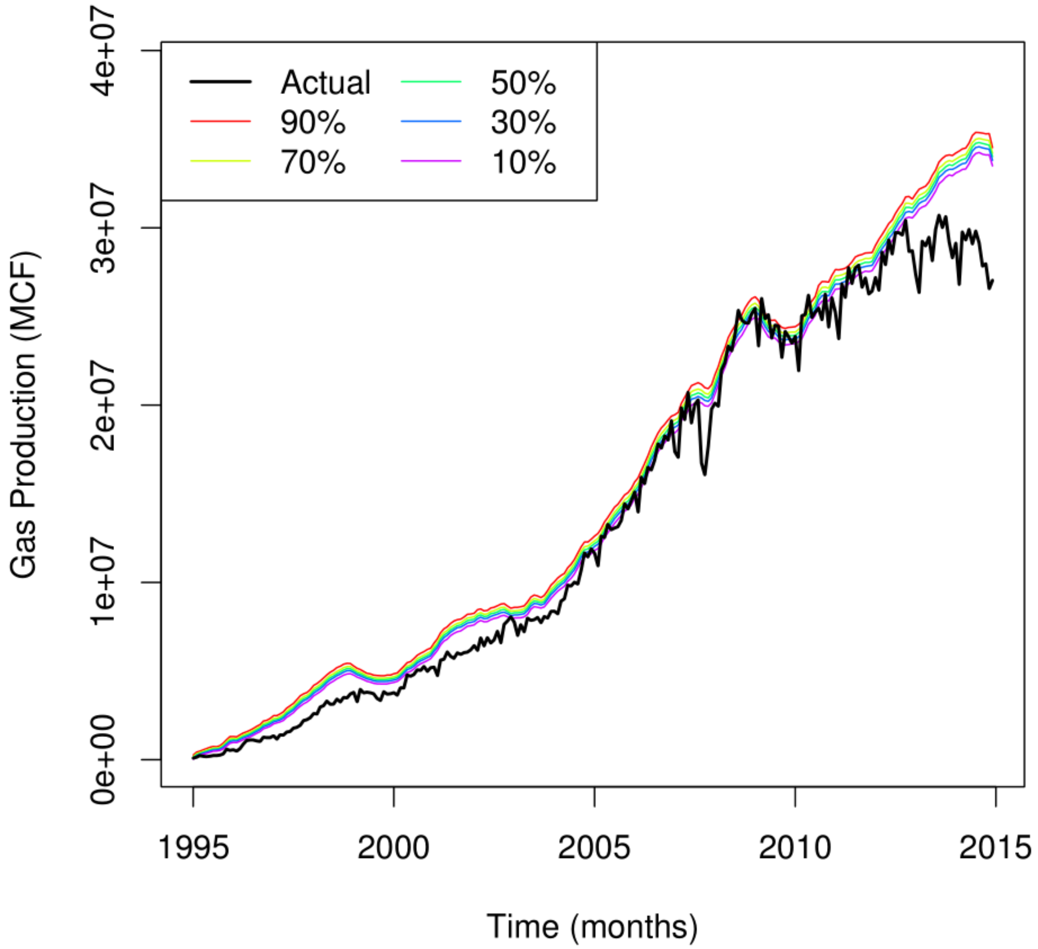


New Wells – 20 years

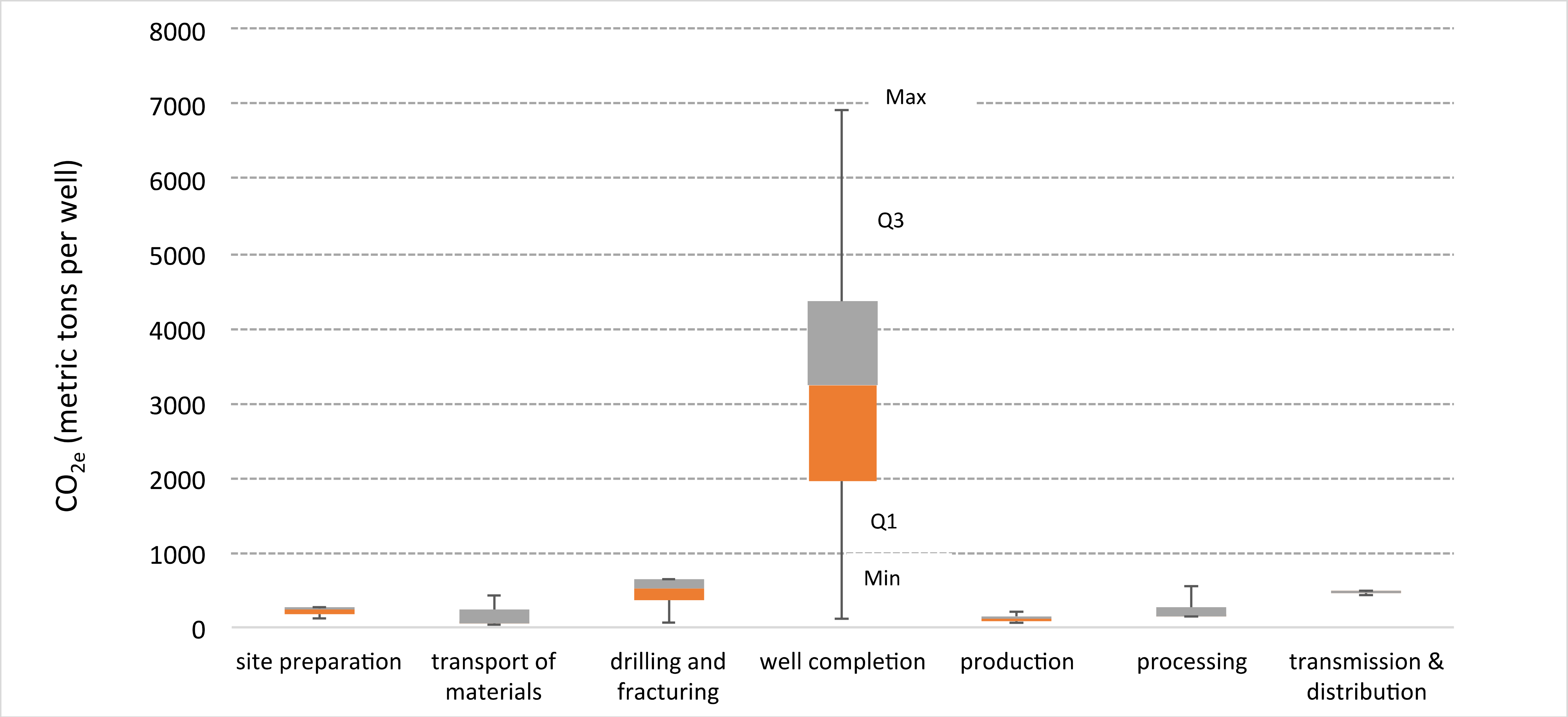
Oil



Gas

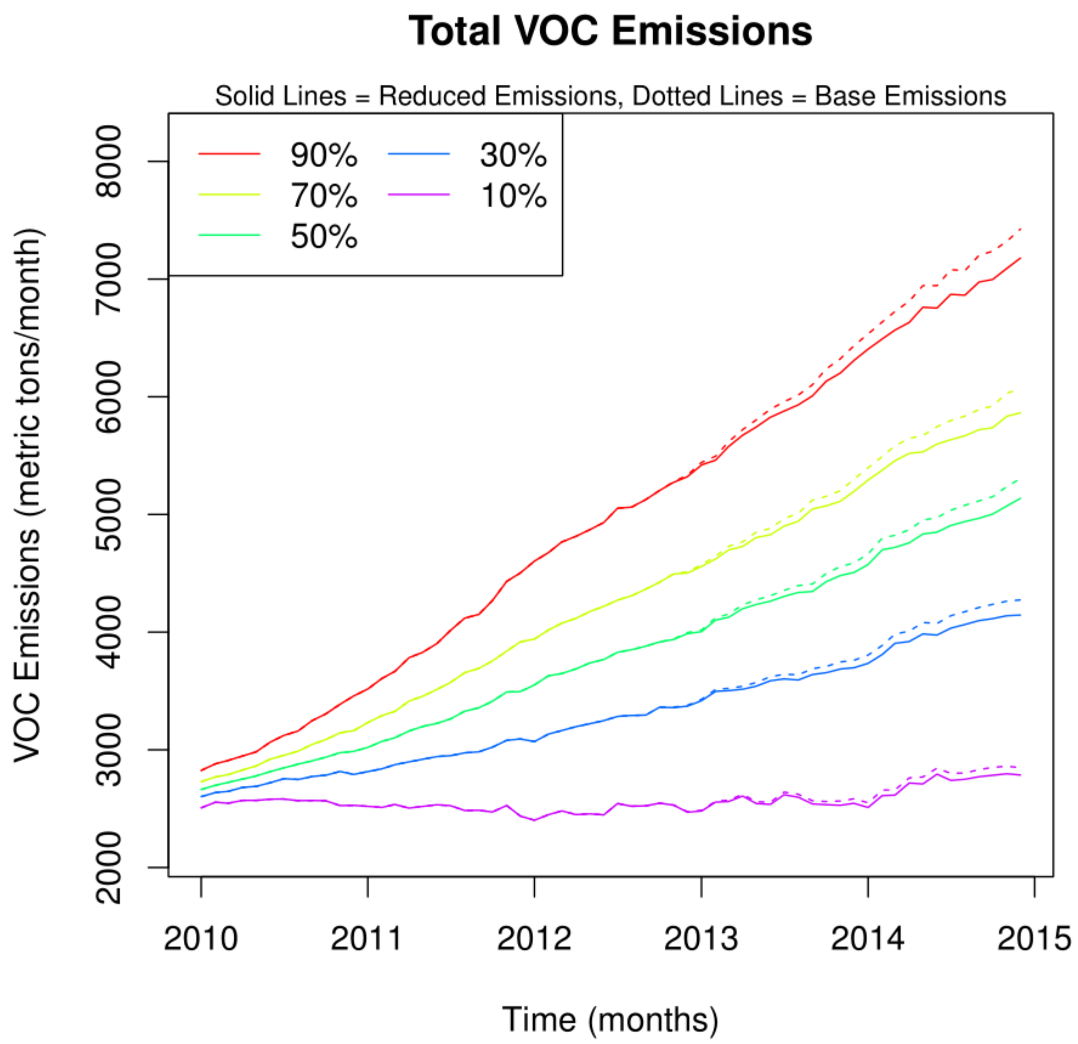


Emissions Factors



Emissions Results

- Calculate emissions from production volumes, drilling schedule, and emission factors
- Can test possible impact of emission reductions by…
  - Emission factor category
  - Well type
  - Location / jurisdiction
  - Time



Conclusions

- Existing model can make long-term projections
  - Uncertainty increases as the projection horizon lengthens
    - Energy price forecast is most important source of error
    - Other important sources
      - Technology change in production rates from new / reworked wells
      - Well location and type
        - Assuming that future wells have same distribution as past wells
      - Extrapolation limits on decline curve analysis
  - Long term projections are still useful
    - Consistent, transparent, repeatable methodology
    - Editable input parameters allow testing and incorporation of new knowledge